Universal Serial Bus
Device Class Definition
for
Display Devices

0.9 Draft Revision
February 1, 1996

Scope of this Revision

The 0.9 release candidate of this definition is intended for industry review.

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Revision History

Revision	Date	Filename	Comments
0.9	2/1/96	usb_dis9.doc	Draft for industry review.

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1. Introduction

The Universal Serial Bus (USB) is a communications architecture that gives a PC the ability to interconnect a variety of devices via a simple four-wire cable. The USB is actually a two-wire serial communication link that runs at 12 megabits (Mbs) per second. USB protocols can configure devices at startup or when they are plugged in at run time. These devices have been broken into various classes, such as display, communication, audio, mass storage, and human interface. A device class defines common functions and protocols for devices that serve similar functions.

1.1 Scope

This document describes the Video Display class of USB devices. It defines the communication with display devices within the USB protocol.

All display devices are meant to view the video output of a PC. In principle, this category of device can be split into three subclasses:

- CRT-based displays
- Flat-panel displays
- Stereoscopic (3-D) displays

1.2 Purpose

This document defines the communication between the USB host and a video display device. It specifies the way in which a display should respond to the host when initializing the USB connection, and the way in which the USB manager can influence the standard features available in the display.

1.3 Related Documents

This specification refers to the following documents:

- *Universal Serial Bus Specification* 1.00 (also referred to as the *USB Specification*). In particular, see Chapter 9, “USB Device Framework.”
- *VESA Display Data Channel Standard*
- *VESA Extended Display Identification (EDID) Standard*
- *VESA Display Information Format (VDIF) Standard*

1.4 Terms and Abbreviations

This section defines terms and abbreviations that are specific to this document. For additional terms related to the USB, see Chapter 2, “Terms and Abbreviations,” in the *USB Specification.*

3-D	Three-dimensional
CRT	Cathode ray tube

2. Overview

This document specifies setting up the communication and control of the display device used to interact with the PC, in order to define a universal interface capable of accommodating any PC peripheral.

Historically, displays have provided hardware control panels to accomplish these device adjustments. Using the computer in addition to these manual controls increases user convenience.

The specification of all the possible communication is split up hierarchically. The highest level is the USB-specific communication between the display and the host, such as product identification and bandwidth requirements. The next level is communication related to display control such as resolution, brightness, and contrast.

3. Functional Characteristics

Display devices enable the user of an application to view the results of the actions taken. The sole purpose of a display device is to present to the user the video contents supplied by the host system. Display devices typically include a number of user controls to set brightness, contrast, picture size, position, and color balance. In addition, displays frequently have a number of internal settings that are changed to optimize operation with different video display formats. It is desirable for the computer system to be able to control these settings directly, as well as to be able to read timing characteristics from the display.

3.1 Operational Model

The communication between the host and the display consists only of control transfers and does not require any other interface than pipe zero. Display adjustments are relative, not absolute. Due to analog variations, support of multiple resolutions, and refresh rates, display commands are in terms of full scale. For example, if the display allows 10 bits of vertical position adjustment the host may select any one of 1024 positions.

To enable the host to issue commands that refer to these controls, the display has to specify the maximum value of each control. The display specifies these maximum values on request. The minimum value is zero.

This process is part of the initialization. After all of the available controls are identified, the host can inquire for the current setting of the controls, store the settings, and change the settings.

In addition to the virtual controls of the display, which can all have a wide range of possible values, the display is equipped with a number of settings which are either enabled or disabled. These settings are regarded as part of the display’s status. The display informs the host of its current status by using a specific order, predefined according this specification. The status settings of the display can be changed by using specific commands.

Finally, if the display is supplying power to a self-powered hub, provisions must be taken to prevent the display from going into its DPMS power-off mode, thereby disconnecting the hub from sufficient power without consulting the USB host.

4. Descriptors

4.1 Standard Descriptors

The Video Display device class uses the following USB standard descriptors:

- Device
- Configuration
- Interface
- Endpoint
- String

For general information about these descriptors, see Chapter 9, “USB Device Framework,” in the USB Specification.

4.1.1 Device Descriptor

The Device descriptor provides general information about the Video Display device.

Table 4-1 Device Descriptor Values

Offset	Field	Size	Value	Value in this class
0	bLength	1	Number	Size of this descriptor in bytes (18)
1	bDescriptorType	1	Constant	DEVICE descriptor type (1)
2	bcdUSB	2	BCD	USB Specification Release Number in Binary-Coded Decimal (i.e. 1.00 is 0x110)
4	bDeviceClass	1	Class	MONITOR (4) (Video Display class code, assigned by the USB)
5	bDeviceSubClass	1	Number	CRT:1, FPD: 2, 3-D: 3
6	bDeviceProtocol	1	Protocol	Protocol code, assigned by the USB (Zero per class specification on interface)
7	wMaxPacketSize0	1	Number	8
8	idVendor	2	ID	Vendor ID (assigned by the USB)
10	idProduct	2	ID	Produce ID (assigned by the vendor)
12	bcdDevice	2	BCD	Device release number in Binary-Coded Decimal (assigned by the vendor)

Table 4-1 Device Descriptor Values (continued)

Offset	Field	Size	Value	Value in this class
14	iManufacturer	1	Index	Index of a string descriptor that describes the manufacturer
15	iProduct	1	Index	Index of a string descriptor that describes the product
16	iSerialNumber	1	Index	Index of a string descriptor that describes the device's serial number
17	bNumConfigurations	1	Number	1

4.1.2 Configuration Descriptor

The Configuration descriptor provides information about the standard configuration for the Video Display device.

Table 4-2 Configuration Descriptor Values

Offset	Field	Size	Value	Value in this class
0	bLength	1	Number	Size of this descriptor in bytes (9)
1	bDescriptorType	1	Constant	CONFIGURATION descriptor type (2)
2	wTotalLength	2	Number	Total length of data returned for this configuration. For details, see Section 9.7.2 in the *USB Specification*.
4	bNumInterfaces	1	Number	1
5	bConfigurationValue	1	Number	1
6	iConfiguration	1	Index	Index of a string descriptor that describes this configuration
7	bAttributes	1	Bitmap	Configuration characteristics. For details, see Section 9.7.2 in the *USB Specification*.
8	MaxPower	1	mA	Maximum power consumption of the display device from the bus in this configuration when the device is fully operational. For details, see Section 9.7.2 in the *USB Specification*. This value is determined by the vendor.

4.1.3 Interface Descriptor

The Interface descriptor describes a specific interface provided by its associated configuration.

Table 4-3 Interface Descriptor Values

Offset	Field	Size	Value	Value in this class
0	bLength	1	Number	Size of this descriptor in bytes (7)
1	bDescriptorType	1	Constant	INTERFACE descriptor type (4)
2	bInterfaceNumber	1	Number	Number of this interface (assigned by vendor)
3	bAlternateSetting	1	Number	Value used to select alternate setting for this interface (assigned by vendor)
4	bNumEndpoints	1	Number	0 (This interface uses only endpoint zero.)
5	bInterfaceClass	1	Class	0
6	bInterfaceSubClass	1	SubClass	0
7	bInterfaceProtocol	1	Protocol	Protocol code, assigned by USB. For details, see Section 9.7.3 in the *USB Specification*.
6	iInterface	1	Index	Index of a string descriptor that describes this interface

4.1.4 Endpoint Descriptor

The interface for the Video Display device class uses only endpoint 0, so no endpoint descriptor is required.

4.1.5 String Descriptor

The string descriptor provides a displayable string that corresponds to a reference field in another descriptor.

Table 4-4 Standard String Descriptor Values

Offset	Field	Size	Value	Value in this class
0	bLength	1	Number	Size of this descriptor in bytes (bString + 2)
1	bDescriptorType	1	Constant	STRING descriptor type (3)
2	bString	N	Number	A UNICODE-encoded string

4.2 Class-Specific Descriptors

The Video Display device class uses the following class-specific descriptors:

- Display
- Display Status
- Display Control

4.2.1 Display Descriptor

The Display descriptor is based on the *VESA Extended Display Identification* (EDID) specification. For details, see that document.

Table 4-5 Display Descriptor Values

Offset	Field	Size	Value	Value in this class
0	bLength	1	Number	Number of bytes in this descriptor (bDisplayCharacteristics + 10)
1	bDescriptorType	1	Constant	6
2	bVirtualControlSupport	8	Bitmap	See Table 4.6, “bVirtualControlSupport Values”
10	bDisplayCharacteristics	128 to 2176	EDID / EDID and VDIF	See VESA standards

Table 4.6 represents a bitmap of **bVirtualControlSupport** that indicates the position of all possible control codes. For a table of currently supported control codes, see Appendix A, “Display Control Codes.” Control codes not listed in Appendix A are reserved for future use.

Table 4-6 bVirtualControlSupport Values

	D7	D6	D5	D4	D3	D2	D1	D0
Byte 1	0E	0C	0A	08	06	04	02	00
Byte 2	1E	1C	1A	18	16	14	12	10
Byte 3	2E	2C	2A	28	26	24	22	20
Byte 4	3E	3C	3A	38	36	34	32	30
Byte 5	4E	4C	4A	48	46	44	42	40

Table 4-7 bVirtualControlSupport Values (continued)

	D7	D6	D5	D4	D3	D2	D1	D0
Byte 6	5E	5C	5A	58	56	54	52	50
Byte 7	6E	6C	6A	68	66	64	62	60
Byte 8	7E	7C	7A	78	76	74	72	70

4.2.2 Display Status Descriptor

The Display Status descriptor determines the way in which the display informs the host of its current status.

Table 4-8 Display Status Descriptor Values

Offset	Field	Size	Value	Description
0	bLength	1	Number	Number of bytes in this descriptor (7)
1	bDescriptorType	1	Constant	7
2	bCurrentStatus	1	Bitmap	The status of the display device's settings. D7: On Screen Display 0 Disabled 1 Enabled D6: Auto Size Center 0 Disabled 1 Enabled D5: Polarity Horizontal Synchronization 0 Negative 1 Positive D4: Polarity Vertical Synchronization 0 Negative 1 Positive D3..2: Synchronization Type 00 Separate 01 Digital Composite 10 Composite on Green 11 Reserved D1..0: DPMS Power Status 00 On 01 Standby 10 Suspend 11 Off
3	bHorFrequency	2	Number	Horizontal frequency in 0.01kHz.
5	bVertFrequency	2	Number	Vertical frequency in 0.01Hz

4.2.3 Display Control Descriptor

The Display Control descriptor informs the host about the possible values of the controls supported by the display device. The minimum value of each control is zero.

Table 4-9 Display Control Descriptor Values

Offset	Field	Size	Value	Description
0	bLength	1	Number	Number of bytes in this descriptor (7)
1	bDescriptorType	1	Constant	9
2	bControlCode	2	Number	See Appendix A, “Display Control Codes”
4	bTypeofValue	1	Number	Determines the meaning of the value given: 0 Maximum value 1 Current value
5	bValue	2	Number	Relevant value for this control

5. Requests

5.1 Standard Requests

The Video Display device class supports the USB standard requests described in the USB Specification. For details, see Chapter 9, “USB Device Class Framework.”

5.2 Class-Specific Requests

The Video Display device class supports the following class-specific requests:

- **GetDisplayID**
- **GetMax**
- **GetCurrent**
- **SetCurrent**
- **GetDisplayStatus**
- **Degauss**
- **SetDisplayPowerMode**

5.2.1 GetDisplayID

GetDisplayID returns either EDID or VDIF information as specified in the Device descriptor.

Table 5-1 GetDisplayID Values

Offset	Field	Size	Value	Description
0	bRequestType	1	10100000	Characteristics of request: D7=1 Transfer is device to host D6..5=01 Type is Class D4..0=00000 Recipient is device
1	bRequest	1	cGetDisplayID	Request code for this request
2	wValue	2	0	N/A
4	wIndex	2	0	N/A
6	wLength	2	129 or 2177	See Display descriptor

5.2.2 GetMax

GetMax requests the possible value of the virtual controls supported by the display device. The device returns the Display Control descriptor.

Table 5-2 GetMax Values

Offset	Field	Size	Value	Description
0	bRequestType	1	10100000	Characteristics of request: D7=1 Transfer is device to host D6..5=01 Type is Class D4..0=00000 Recipient is device
1	bRequest	1	cGetMax	Request code for this request
2	wValue	2	Number	See Appendix A, “Display Control Codes”
4	wIndex	2	0	N/A
6	wLength	2	7	See the Display Control descriptor

5.2.3 GetCurrent

GetCurrent requests the current value of the virtual controls supported by the display device. The device returns the Display Control descriptor.

Table 5-3 GetCurrent Values

Offset	Field	Size	Value	Description
0	bRequestType	1	10100000	Characteristics of request: D7=1 Transfer is device to host D6..5=01 Type is Class D4..0=00000 Recipient is device
1	bRequest	1	cGetCurrent	Request code for this request
2	wValue	2	Number	See Appendix A, “Display Control Codes”
4	wIndex	2	0	N/A
6	wLength	2	7	See the Display Control descriptor

5.2.4 SetCurrent

SetCurrent sets the current values of the virtual controls supported by the display device. The host uses the Display Control descriptor to set the new value(s).

Table 5-4 SetCurrent Values

Offset	Field	Size	Value	Description
0	bRequestType	1	00100000	Characteristics of request: D7=0 Transfer is host to device D6..5=01 Type is Class D4..0=00000 Recipient is device
1	bRequest	1	cSetCurrent	Request code for this request
2	wValue	2	Number	See Appendix A, “Display Control Codes”
4	wIndex	2	0	N/A
6	wLength	2	7	See the Display Control descriptor

5.2.5 GetDisplayStatus

GetDisplayStatus returns information on enable/disable features of the display device. This request is issued by the host to get information on the current situation on the features defined in the Display Status descriptor.

Table 5-5 GetDisplayStatus Values

Offset	Field	Size	Value	Description
0	bRequestType	1	10100000	Characteristics of request: D7=1 Transfer is device to host D6..5=01 Type is Class D4..0=00000 Recipient is device
1	bRequest	1	GetDisplayStatus	Request code for this request
2	wValue	2	0	0: values of all controls are set
4	wIndex	2	0	N/A
6	wLength	2	20	See the Display Status descriptor

5.2.6 Degauss

Degauss is the only request that does not change the value of a parameter. It causes the display to degauss and does not alter any of its control or status values.

Table 5-6 SetDisplayPowerMode Values

Offset	Field	Size	Value	Description
0	bRequestType	1	00100000	Characteristics of request: D7=1 Transfer is host to device D6..5=01 Type is Class D4..0=00000 Recipient is device
1	bRequest	1	Degauss	Request code for this request
2	wValue	2	0	N/A
4	wIndex	2	0	N/A
6	wLength	2	0	No data transfer

5.2.7 SetDisplayPowerMode

SetDisplayPowerMode causes the display device to change its power status. The four different power modes defined in the VESA DPMS proposal, can be chosen with this request.

Table 5-7 SetDisplayPowerMode Values

Offset	Field	Size	Value	Description
0	bRequestType	1	00100000	Characteristics of request: D7=1 Transfer is host to device D6..5=01 Type is Class D4..0=00000 Recipient is device
1	bRequest	1	SetPowerMode	Request code for this request
2	wValue	2	Number	Value of request: 0 ON 1 Stand by 2 Suspend 3 OFF
4	wIndex	2	0	N/A
6	wLength	2	0	No data transfer

Appendix A Display Control Codes

Display control codes indicate the control commands supported by a display device. These codes are specified in the **bVirtualControlSupport** field of the Display descriptor. For details about the Display descriptor, see Section 4.2.1 in this document. For details about control codes, see the *VESA Extended Display Identification (EDID) Standard* and the *VESA Display Information Format (VDIF) Standard*.

Table A.1 Display Control Code Values

Code	Field	Size	Value	Description
10h	Brightness	2	Number	The black level luminance of the display.
12h	Contrast	2	Number	The ratio between the maximum and minimum luminance values.
16h	Red Video Gain	2	Number	The level of maximum luminance of red pixels.
18h	Green Video Gain	2	Number	The level of maximum luminance of green pixels.
1Ah	Blue Video Gain	2	Number	The level of maximum luminance of blue pixels.
6Ch	Red Video Black Level	2	Number	The level of minimum luminance of red pixels.
6Eh	Green Video Black Level	2	Number	The level of minimum luminance of green pixels.
70h	Blue Video Black Level	2	Number	The level of minimum luminance of blue pixels.
1Ch	Focus	2	Number	Adjusts the apparent spot size.
20h	Horizontal Position	2	Number	Moves the image toward the right side of the display.
22h	Horizontal Size	2	Number	The distance between the left and right sides of the image.
24h	Horizontal Pincushion	2	Number	Causes the right and left sides of the image to become more or less convex.
26h	Horizontal Pincushion Balance	2	Number	Moves the center section of the image toward the right or left side of the display.
28h	Horizontal Misconvergence	2	Number	Increasing (decreasing) this value will shift the red pixels to the right (left) across the image and the blue pixels left (right) across the image with respect to the green pixels.
2Ah	Horizontal Linearity	2	Number	Shifts the density of pixels from the left and right ends to the center of the image.

Table A.1 Display Control Code Values (continued)

Code	Field	Size	Value	Description
2Ch	Horizontal Linearity Balance	2	Number	Increasing (decreasing) this value shifts the density of pixels from the left (right) side to the right (left) side of the image.
30h	Vertical Position	2	Number	Increasing (decreasing) this value moves the image toward the top (bottom) of the display.
32h	Vertical Size	2	Number	The distance between the top and bottom of the image.
34h	Vertical Pincushion	2	Number	Increasing (decreasing) this value causes the top and bottom sides of the image to become more (less) convex.
36h	Vertical Pincushion Balance	2	Number	Increasing (decreasing) this value moves the center section of the image toward the top (bottom) of the display.
38h	Vertical Misconvergence	2	Number	Increasing (decreasing) this value shifts the red pixels up (down) across the image and the blue pixels down (up) across the image with respect to the green pixels.
3Ah	Vertical Linearity	2	Number	Increasing (decreasing) this value shifts the density of scan lines from the ends (center) to the center (ends) of the image.
3Ch	Vertical Linearity Balance	2	Number	Increasing (decreasing) this value shifts the density of scan lines from the top (bottom) end to the bottom (top) end of the image.
40h	Parallelogram Distortion (Key Balance	2	Number	Increasing (decreasing) this value shifts the top section of the image to the right (left) with respect to the bottom section of the image.
42h	Trapezoidal Distortion (Key)	2	Number	The ratio between the horizontal size at the top of the image relative to the horizontal size at the bottom of the image.
44h	Tilt (Rotation)	2	Number	Increasing (decreasing) this value rotates the image (counter) clockwise about the center point of the image.
46h	Top Corner Distortion Control	2	Number	The distance between the left and right side at the top end of the image.
48h	Top Corner Distortion Balance	2	Number	Increasing (decreasing) this value moves the top end of the image to the right (left).

Table A.1 Display Control Code Values (continued)

Code	Field	Size	Value	Description
4Ah	Bottom Corner Distortion Control	2	Number	The distance between the left and right side at the bottom end of the image.
4Ch	Bottom Corner Distortion Balance	2	Number	Increasing (decreasing) this value moves the bottom end of the image to the right (value).
56h	Horizontal Moiré	2	Number	Adjusting this value controls the horizontal picture moiré cancellation.
58h	Vertical Moiré	2	Number	Adjusting this value controls the vertical picture moiré cancellation.
5Eh	Input level Select	2	Bitmap	Changing this value chooses a different video input voltage for the display. Format is *reference white above blank*,*level of sync. below blank*. D15 0.700 , 0.300 (1.00 Vpp) D14 0.714 , 0.286 (1.00 Vpp) D13 1.000 , 0.400 (1.40 Vpp)
60h	Input Source Select	2	Bitmap	Changing this value selects a different video input source. D15 VGA D14 RGB D13 EVC D12 MAC D11 RCA/ Composite Video D10 S-Video D9 SCART
6Ah	StereoMode	2	Bitmap	Changing this value selects the video mode with respect to 2D or 3D. D15 Mono Mode D14 Enable Field-Sequential Right Eye First D13 Enable Field-Sequential Left Eye First D12 Enable 2-Way Interleaved Right Eye First D11 Enable 2-Way Interleaved Left Eye First D10 Enable 4-Way Interleaved, Display Stereo Buffer 0 (even scan lines) D9 Enable 4-Way Interleaved, Display Stereo Buffer 1 (odd scan lines) D8 Enable Side-by-Side Interleaved

Appendix B Class Request Codes

TBD

Appendix C Error Codes

TBD